

Coastal Aerosol Distribution by Data Assimilation

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LONG-TERM GOALS

The long-term goal of this research is to develop an initialization scheme for a multi-dimensional, predictive aerosol model in coastal regions. The initialization scheme will have global coverage and include data gathering, quality control and data assimilation of the available aerosol observations, including satellite aerosol retrievals, ground-based remote sensing, point measurements, and the previous aerosol forecast.

OBJECTIVES

The objectives of this program are to (1) investigate and evaluate the existing and proposed aerosol retrievals from satellites for applicability to aerosol model initialization and (2) develop and test aerosol analysis and data assimilation techniques using satellite and other aerosol measurements.

APPROACH

The approach to the problem of aerosol and Electro-Optical (EO) extinction prediction follows that used in numerical weather prediction, namely real-time assessment and first-principle modeling. A predictive model requires the initial spatial distribution of the aerosol field including composition, concentration, and size distribution. Sensors and retrieval techniques exist for obtaining the aerosol optical depth (AOD) and some information about particle size. The remotely sensed aerosol properties typically are vertical integrals and are generated at horizontal resolutions ranging from one kilometer to one degree. An objective analysis method is being devised to merge these 2-D distributions with point measurements and model constraints to produce a three-dimensional description of aerosols.

WORK COMPLETED

The Navy Aerosol Analysis and Prediction System (NAAPS) continues to be developed, improved and tested. NAAPS was utilized during the Aerosol Characterization Experiment in Asia (ACE-Asia) in March and April of 2001 to forecast aerosol events five days in advance.

A program to retrieve aerosol optical depth from AVHRR and GOES satellite data has been evaluated for the tropical Atlantic and improvements have been implemented. Data collected during the Puerto Rico Dust Experiment (PRIDE) have been used to evaluate the retrieval and guide the improvements.

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The Wildfire-ABBA (Automated Biomass Burning Algorithm) product for fire detection in the western hemisphere from GOES data is now received every half hour at NRL/MRY from University of Wisconsin. This product is used to specify western hemisphere smoke sources in NAAPS. A historical dataset (1993) for fires in Africa, based on AVHRRR data, from ESA, is still used to specify smoke sources in Africa, Australia and Indonesia. A program to detect biomass fires from NAVO AVHRR GAC data has been ported to NRL and is being implemented to provide global coverage for smoke sources. AVHRR Global Area Coverage (GAC) data are being received daily from Naval Oceanographic Office (NAVO) for use in implementing optical depth retrieval and fire detection algorithms. The retrieval and detection algorithms were developed for high resolution AVHRR data and must be modified to use the coarser GAC data.

Region-specific web pages are being developed. These contain only the products relevant to a particular region on the single page. This approach can facilitate the analyses of aerosol events for a particular region. These would be templates for METOC and warfighter specific pages that would be distributed on SIPRNET. The original 'all-regions' web page is still available.

RESULTS

Numerous dust and pollution events were simulated during ACE-Asia (Figure 1). The NAAPS forecasts were used to choose aircraft flight days and stand-down days. In one instance, NAAPS correctly modeled the transport of Asian aerosols as Far East as the Western Atlantic Ocean. Until recently, such long-range transport was not considered possible in the troposphere, but NAAPS along with several recent satellites, have demonstrated that these events are occurring numerous times each year. Explaining the long tropospheric lifetime of these aerosols is the focus of a 6.1 program.

Our analysis of AOD retrieved from AVHRR and GOES has revealed several problems with the data and the algorithm. The data were available only in 8-bit format at first, but our study showed that the full 10-bit data were necessary to retrieve AOD with precision. We also discovered a problem in diagnosing the optical properties of the aerosol. Validation of the algorithm is now proceeding using airborne and surface sun photometer data collected during PRIDE.

The NAVO GAC data are valuable because it gives full global coverage. However, in the conversion to GAC resolution, NOAA utilizes only 4 pixels out of every 3 x 5 block. Fires often cover only a single pixel, except in boreal regions where fires are often much larger. Thus this dataset will retrieve less than 27% of the possible small fires on average. Nevertheless, we are pursuing this approach to give us some information in areas not covered by Wildfire-ABBA. We have also begun pursuing the MODIS fire product from C. Justice (U. Md.) which also has daily, global coverage, but at 1-km horizontal resolution.

IMPACT/APPLICATIONS

Presently, NAAPS runs in a predictive mode and can help to satisfy the Navy's long-term goal of a predictive capability for aerosols and EO propagation. This research also provides tools for the 6.1 and 6.2 aerosol research communities and the academic community. NAAPS will be transitioned to operations over the next two years. Over the past year, collaborations have been initiated between NRL and University of Miami, U. Wisc., U. Alabama, NASA/GSFC and others. NRL's participation

in ACE-Asia will give us further opportunities for collaboration and access to important validation data.

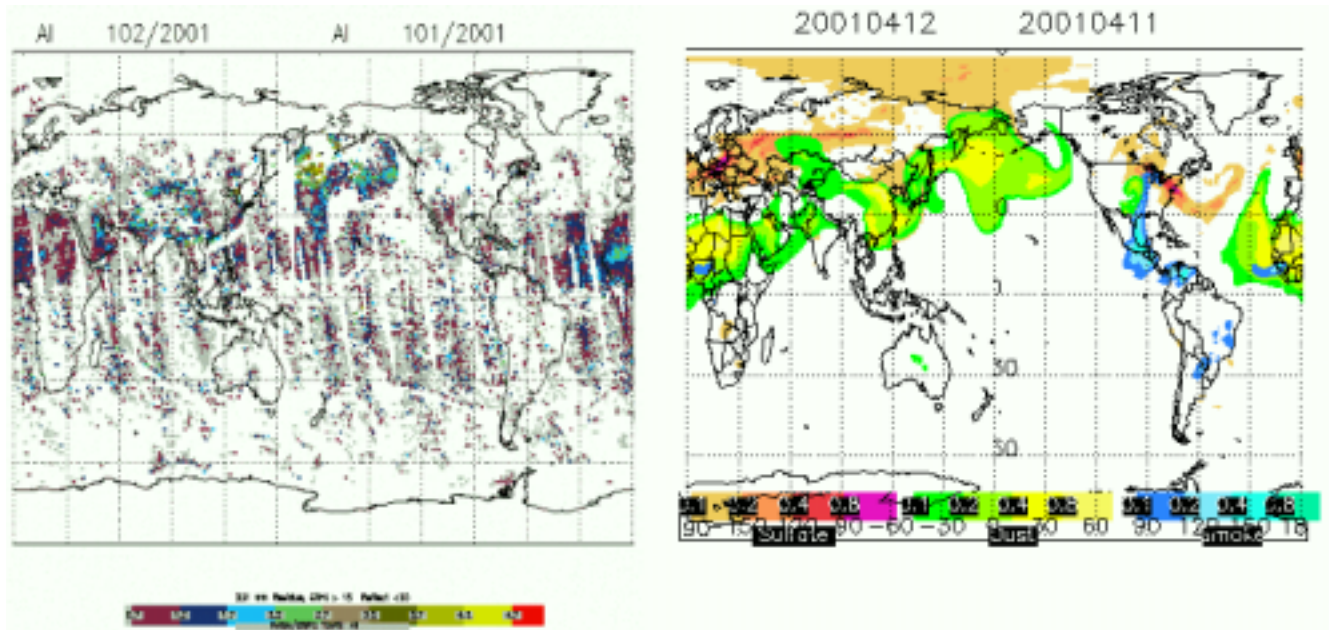


Figure 1. The left panel shows the satellite retrieval (uncalibrated) of amount of absorbing aerosol (dust and smoke) for April 12, 2001. We see dust over the North Pacific Ocean, central Asia, southwest Asia, and over most of North Africa. The right panel shows the NAAPS simulated distribution of dust (green and yellow shades), smoke (blue shades) and sulfate (red shades) aerosols for the same time. NAAPS shows good agreement with the satellite, and also fills in the gaps in the satellite data that were caused by clouds and the viewing characteristics of the satellite. NAAPS accurately predicted the transport of the dust in the North Pacific to the East Coast of the United States four days later.

TRANSITIONS

None.

RELATED PROJECTS

The NRL 6.1 Atmospheric Physics, NRL 6.2 Mesoscale Modeling of the Atmosphere and Aerosols use NAAPS products and the satellite retrievals for investigations and validation. The 6.2-6.4 EO Prediction RTP will transition the model to operations and use it to generate products for use by the fleet.

SUMMARY

A global predictive model of tropospheric aerosols has been developed over the past several years. Improvements have been made this year to the source functions, validation techniques, and product distribution. With its global, continuous coverage, NAAPS is invaluable in filling the gaps in observations of aerosols and visibility and in satellite observations and extends our understanding of aerosols and their impact on Navy operations. NAAPS simulations have revealed that inter-continental transport of aerosols is common and occurs nearly every day somewhere in the world. Over the next two years, a salt aerosol will be added and the global, real-time fire detection will be completed. These improvements will make the model's forecasts even more accurate.

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None.

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